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DEVELOPMENT AND FABRICATION OF COMPOSITIONS FOR 155-MM MODULAR PROPELLING CHARGES

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

To determine optimum composition for 155-mm modular charges, a variety of compositions were tested in accordance with the scope of the contract.

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MANUFACTURING PROCESS

The beater additive, molded-fiber process is a manufacturing process for making molded products using modified pulp and paper-making procedures to produce an end product from mixed fibers and plastic resins.

The basic raw materials are nitrated cotton linters (nitrocellulose), natural cellulose fibers (sulfite Kraft), mechanically reduced natural cellulose fibers (shredded wood), etc., plus synthetic fibers such as polyesters, acrylics, and others. Emulsified resins are added as binders for strength, moisture repellency, and other desirable characteristics. The natural fibers are hydrated and reduced to their unrefined state (i.e., individual fibers) in a beater with water to the freeness required by subsequent processing.

The equipment used for this preprocessing is the deflaker. This piece of equipment consists of a tank for slurrying the synthetic fiber and deflaking unit which uses a combination of hydraulic and mechanical forces to "nick" and/or "peel" the individual fiber strands between two toothed plates without cutting or breaking them completely, thus providing more surface area on each fiber for better orientation during the felting operation. The deflaked (fibrillated) areas in the fibers also provide niches to which resin particles adhere during resin precipitation.

The natural and prepared synthetic fibers are brought together by means of pumps from their respective tanks to a larger precipitation tank and slurried together with the addition of resin emulsion (fig. 1). Nitrocellulose may be added at this point but is generally added to the natural fiber slurry in the beater and mixed momentarily prior to pumping of that mixture to the precipitation tank.

The resin is added to the slurry at this time along with the necessary chemicals and ionically precipitated to the individual fibers. Resin particles may be precipitated to the individual fibers, either anionically or cationically, dependent on resin system used. Best results are obtained with smaller resin particles forming a sheath around each individual fiber, thus preventing mechanical dislodging of the resin from the fibers during subsequent processing. Nitrocellulose stabilizers are also added during the precipitation process. The slurry batch is transferred by pump from the precipitation tank to a large slurry supply tank where it is diluted with water to the proper consistency for the felting operation which follows. A consistency of 0.2% to 0.4% is generally used although thinner or heavier consistencies are feltable. Ideal consistency is largely dependent on product configuration.

The slurry batch is then pumped to the preforming tank. The slurry enters the tank at the bottom, fills it and overflows into a trough around the top circumference of the tank, creating a weir action. The slurry then flows to a pump where the material is returned to the supply tank on a continuous basis. This in-flow/out-flow of slurry provides the agitation required to keep the fibers in uniform suspension in the water. Auxiliary agitation may be necessary.

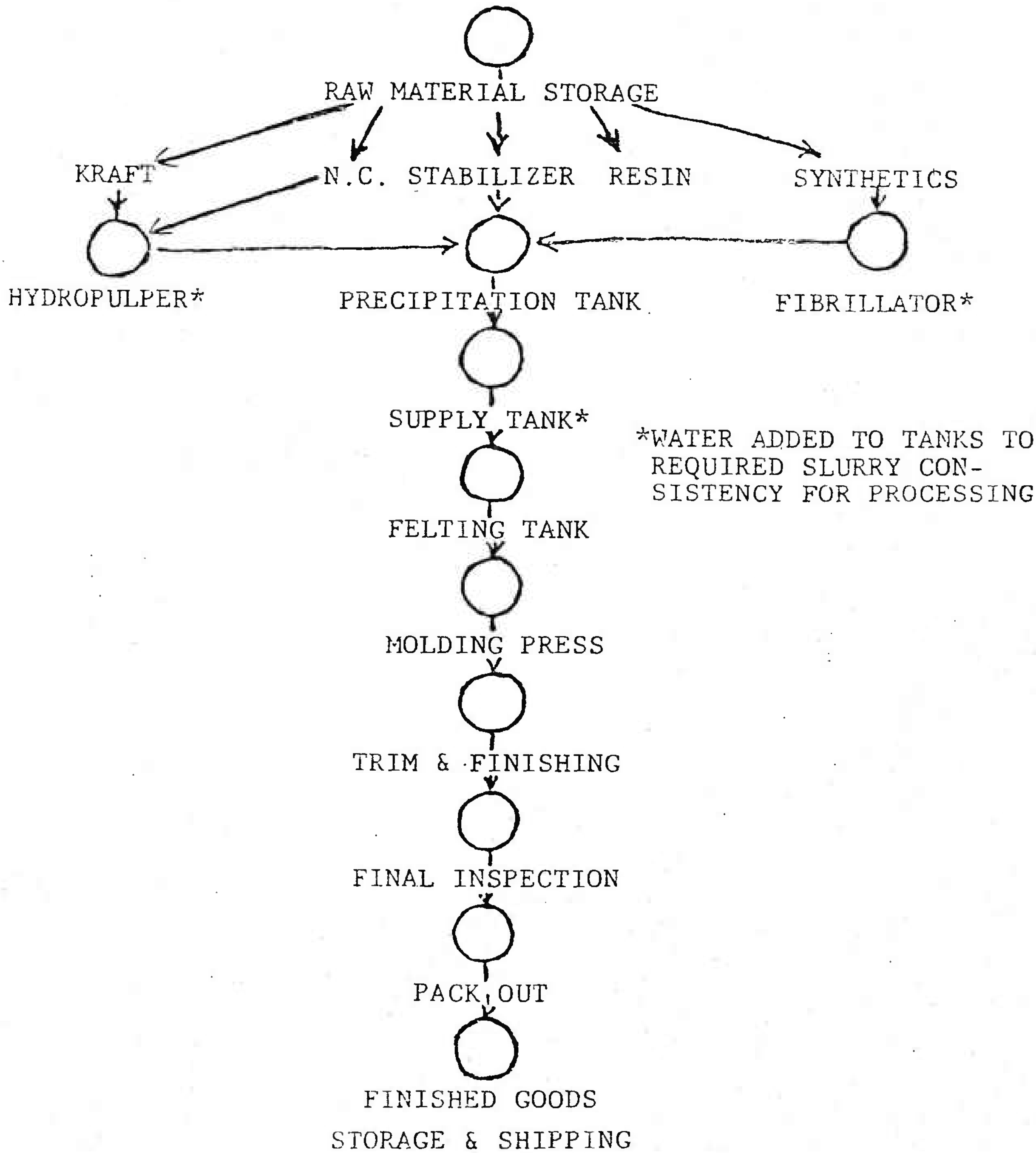

Figure 1. Beater addition flow chart

The preforming die (felter) consists of a hollow, perforated form contoured to the part configuration, and covered with fine mesh screen. A vacuum line is connected to the hollow cavity of the die. The felting die is immersed into the slurry bath. Water is drawn through the die by vacuum, depositing the resinated fibers on the screen surface. After a predetermined time, the felter is raised out of the slurry with the vacuum still applied for a period of time to remove most of the free water from the resulting preform, leaving a wet felt approximately 60% water, 40% dry fibers and resin. The vacuum is then shut off and a quick low pressure pulse of air is injected into the die cavity, stretching the preform slightly and loosening the resinated fiber from the screen for easy removal of the preform. The wet preform is removed from the felter and placed over the male section of steam-heated matched molding dies designed to produce a molded part to finished product dimensions in a press. The male die contains vertical drainage grooves around its periphery which terminate at the base of the die in a vacuum manifold.

The female die is slowly closed over the felt on the male die, forcing water from the felt through the drainage grooves to the manifold by pressure and vacuum, thus molding the part to finished dimensions. The remaining moisture in the felt is vaporized by die heat and evacuated through the vacuum manifold. The resin in the product is cured at this time by the die heat. After a predetermined time, the dies are opened, a pressure pulse of air injected into die, and the molded part removed. After molding, parts are trimmed and finished as required to finished part configuration. They are inspected physically, compositionally tested as applicable, and packed out.

The case designated was the P/N9328626 body assembly to be made in two different configurations, (-1), and (-2), with each configuration composed of a case body P/N9328623 in two different lengths (-1), and (-2), a base P/N9328625 and a tube P/N9328624 in two different lengths, (-1), and (-2).

Part compositions for the assembly details were varied to include elimination of acrylic fibers in one case, increase of nitrocellulose content, and inclusion of talc into the formula for one required body detail.

Since assembly details were interchangeable, it was felt that this variety of product lengths and compositions would enhance the development of a successful modular case.

Tooling to produce the case was designed and procured. Body tooling was designed to sufficient length that both body configurations could be produced from the same set of tools through trim procedures. No new basic tooling was required to produce the needed tube configuration since tooling was available which could be used with only modifications in trim lengths to be made.

Trim and finishing fixtures for body and base components were made internally and adapted to existing equipment. Calibrated standard inspection tools and equipment were used for all dimensional inspections. Product testing required by contract was conducted, as outlined in table 1.

Raw materials required to formulate the required cases were on hand. These included: nitrocellulose (12.6% N per MIL N 244A), acrylic fiber (MIL F-50533), resin (Durolok resin 42-3001), catalyst (42-2300 National Starch Corporation), Kraft paper (MIL-C-50269), diphenylamine (MIL-D-98), talc (3M $0\text{-}4SiO_2H_2O$, Cypress Industrial, 1 1/2 micron), and necessary batching additives.

Formulations were established to achieve the different compositions required for the products. The formula for the composition B-9247366 was in current use at the time and had been used for some years in the manufacture of a variety of products at Armtec. Variation of formula nitrocellulose content had been achieved on several earlier experimental trials. Talc had been successfully introduced into a product under a previous contract DAAK10-79-C-0013.

The first batch for tool trial was made from production formula (B-9327366). Some difficulty was experienced in the felting of both body and base in the step areas. Separations of the part occurred in the body top depression (hole) during molding. These problems were overcome by felting tool adjustment. Little difficulty was experienced in body component molding considering the straight (cylindrical) and thin sidewall. Tubes were felted and molded as in regular production (table 2).

Table 1. Product requirements under contract scope of work

	Quantity	Component	Dwg. No.	Composition	
(1)	200 ea	Body - 10 in.	9328623-1	(B-9247366)	
	100 ea	Body - 7 in.	9328623-1		
	300 ea	Base	9328625		
	400 ea	Tube - 10 in.	9328624-1		
	200 ea	Tube - 7 in.	9328624-2		
(2)	300 ea	Base	9328625	(0293K)	
(3)	100 ea	Body - 10 in.	9328623-1	(0293KT)	
				Nitrocellulose (12.6%)	72%
				Kraft fiber	17%
				Resin	10%
				Diphenylamine	1%
(4)	100 ea	Body - 10 in.	9328623-1	Nitrocellulose (12.6%)	72%
	100 ea	Body - 7 in.	9328623-2	Kraft fiber	17%
				Resin	10%
				Diphenylamine	1%

Table 2. Felting and molding summary

	Felt Tank	Felt Tool	Form-ula	Cons. %	Felt Vac. "Hg.	Felt Cyc Sec.	Blow Off psi	Press	Ram psi	Mold Oies	Oie Temp °F	Die Vac "Hg.	Ory Cyc Min	Blow Off psi
Task 1 P/N 9328623	P.PLT.	9328623FT	B9247366	.181	25	42	70	P.PLT.	900	9328623MS	250/240	24	4.0	50
Task 2 P/N 9328623	P.PLT	9328623FT	B9247366	.181	25	42	70	P.PLT.	900	9328623MS	250/240	24	4.0	50
Task 3 P/N 9328625	#2	9328625FT	B9247366	.170	25	31	70	P.PLT.	900	9327825MD	250/240	24	3.5	50
Task 4 P/N 9328624	P.PLT.	500040	B9247366	.177	25	47	70	Tube Press	900	500040	250/240	N/A	N/A	N/A
Task 5 P/N 9328624	P.PLT.	500040	B9247366	.180	25	47	70	Tube Press	900	500040	250/240	N/A	N/A	N/A
Task 6 P/N 9328625	#2		0233K	.162	23	35	50	#10	1000		250/240	23	3.5	50
Task 7 P/N 9328623	P.PLT.	9328623FT	0293KT	.171	25	49	50	P.PLT.	900	9328633MS	250/240	24	4.0	50
Task 8 P/N 9328623	P.PLT.	9328623FT	0293K	.170	25	43	50	P.PLT.	900	9328623MS	250/240	24	4.0	50
Task 9 P/N 9328623	P.PLT.	9328623FT	0293K	.181	25	44	50	P.PLT.	900	9328623MS	250/240	24	4.0	50

A total of seven batches were prepared to satisfy product requirements of the contract. For purposes of internal record-keeping and product handling, the product requirement was broken down into nine tasks as shown in table 3.

Table 3. Scope of work

Task	Formula	Part description			Units
1	B-9247366	9328623-1	(10 in.)	Body	200
2	B-9247366	9328623-2	(6 in.)	Body	100
3	B-9247366	9328625		Base	300
4	B-9247366	9328624-1	(10 in.)	Tube	400
5	B-9247366	9328624-2	(7 in.)	Tube	200
6	0293K	9348625		Base	300
7	0293KT	9328623-1	(10 in.)	Body	100
8	0293K	9328623-1	(10 in.)	Body	100
9	0293K	9328623-2	(6 in.)	Body	100

After felting and molding, the components were trimmed to density as necessary. Bodies were lathe-trimmed to configuration length with a special mandrel adapter for mounting. Base tips were trimmed by hand. Production trim tools were adapted to trim tubes. All units were dimensionally inspected to drawings using calibrated Vernier calipers, height gages, pi tapes, and micrometers. All parts were individually weighed. Initial dimensional inspection revealed minor tool modification or remake to correct. The ARRADCOM Project Officer was notified of this and it was decided to proceed with manufacture. Results of dimensional inspections are in table 4.

Product testing for composition (thermal and analysis) was conducted in the Armtec Laboratory on parts from each batch of material formulated. Procedures as outlined in MIL STD 286B were used to analyze for nitrocellulose, diphenylamine, and acrylic fiber (where used). Kraft, resin, and talc are reported as a subtraction value. Batches analyzed have been keyed to the task outline as previously noted. Composition results are in table 5.

Product density was checked in by cutting 1 in. x 3 in. pieces from the top middle and bottom middle of body components and from opposite sides of the large flat area of base. Fiber densities are mathematical in reference to overall dimensions and weight. Product specimens were weighed on a calibrated Ktron C10 electron gram scale, accuracy to 1 gram. Tensile testing was conducted using the same specimens used for density check. The tensile tester was a calibrated Dillon dynamometer with 1 in./min. crosshead speed.

Both density and tensile tests were conducted on parts taken from each batch. Batches have been keyed to the task outline and the results are listed in table 6.

Table 4. Dimensional analysis

	Tasks 1	2	3	4	5	6	7	8	9
P/N/9328623									
A. 5.750±.005	5.741	5.745					5.751	5.748	5.744
B. Overall Length[a]	11.332	8.311					11.318	11.320	2.309
C. Length to Bottom Step[b]	9.980	6.988					9.981	9.977	6.980
D. 1.21 ± .01	1.173	1.188					1.180	1.177	1.175
E. TH .080±.010	.080	.079					.080	.081	.080
F. Igniter Boss Projection	.501	.503					.501	.500	.499
G. Small O.D. 5.565±.005	5.535	5.539					5.537	5.538	5.541
H. Inter Med O.D. 5.750±.005	5.725	5.728					5.730	5.730	5.730
I. O.D. 5.87 Max	OK	OK					OK	OK	OK
J. 1.125±.010	OK	OK					OK	OK	OK
K. .30±.01	.285	.289					.290	.288	.286
P/N 9328625									
L. O.D. 5.750±.005			5.718			5.720			
M. Dept .240±.010			.234			.238			
N. I.D. Cavity 3.00±.01			2.988			2.991			
O. Depth Ign. Cav. 1.09±.02			.952			.977			
P. O/A Ht. 1.500±.020			1.490			1.501			
Q. O.D. Boss 1.13±.005			1.125			1.126			
R. TH .080±.010			.092			.088			
P/N 9328624									
S. Length[c]				9.134	6.250				
T. I.D. 1.30±.010				1.135	1.138				
V. TH .115±.010				.130	.123				

[a] Overall Length Requirement — 11.305 ± .020 for 1 Conf.; 8.300 ± .020 for 2 Conf.

[b] Length to Step Requirement — 9.960 ± .020 for 1 Conf.; 6.985 ± .020 for 2 Conf.

[c] 9.26 ± .02 for 1 Conf.; 6.26 ± .02 for 2 Conf.

Table 5. Composition analysis

			Nitrocellulose		DPA		Acrylic		KRAD*			
									Kraft	resin	talc	
Task	Batch	Formula	req.	test	req.	test	req.	test	req.	req.	req.	Test
1	1218	B9247366	55±2%	56.07	1.0±.3%	1.29	25±2%	23.84	9±2%	10%±2%	0	18.80
2	1218	B9247366	55±2%	56.07	1.0±.3%	1.29	25±2%	23.84	9±2%	10%±2%	0	18.80
3	1220	B9247366	55±2%	54.03	1.0±.3%	1.18	25±2%	25.79	9±2%	10%±2%	0	19.00
4	1700	B9247366	55±2%	54.82	1.0±.3%	124	25±2%	24.89	9±2%	10%±2%	0	19.05
5	1700	B9247366	55±2%	54.82	1.0±.3%	1.24	25±2%	24.89	9±2%	10%±2%	0	19.05
6	001	0293K	72%	73.06	1%	1.11	0	0	17%	10%	0	25.83
7	008	0293KT	64%	69.81	1%	1.47	0	0	15%	10%	10%	28.72
8	003	0293K	72%	72.69	1%	1.06	0	0	17%	10%	0	26.25
9	005	0293K	72%	72.61	1%	1.06	0	0	17%	10%	0	26.33

Stability Test:

Parts from all batches were tested for stability at 134.5°C with certified methyl-violet paper. All passed.

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* Kraft, resin, and additives.

Table 6. Density and tensile analysis

Task	Type	Density (g/cm^2)	Tensile (psi)
1	Body	0.801	3020
2	Body	0.834	3560
3	Body	0.800	3017
4	Body	0.748	--
5	Body	0.737	--
6	Body	0.840	3616
7	Body	0.888	3580
8	Body	0.861	3445
9	Body	0.845	3500

CONCLUSIONS

1. A molded combustible modular charge case with interchangeable charge containers can readily be manufactured.

2. Straight wall (cylindrical) combustible cases can be molded with relatively thin walls.

3. Variations of fiber-binder formulas in the production of molded fiber-type ordnance items appears infinite within the scope of materials used thus far, although additional work is indicated in areas of product shrinkage and strength factors pertaining to formulation.

4. Associated materials (i.e., talc) may be introduced into the formulas, if required.

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